R. Whittier Comments on the 1/11/18 Red Hill Groundwater Modeling Working Group Meeting

Hydraulic Conductivity of Saprolite

There was discussion about the results of the pneumatic small-scale aquifer tests in the saprollite and possibility the results could be biased low by things such as the skin effect on the borehole wall. The average computed hydraulic conductivity for the saprolite was 2.8×10^{-5} ft/d. Other data AECOM has collected indicates a much higher hydraulic conductivity. The depth specific water levels in RHMW11 seems to indicate a unit gradient. A unit gradient is where the change in water level and change in vertical depth are equal. Thus by Darcy's law if the hydraulic gradient equals 1, then the infiltration rate and the hydraulic conductivity are equal. This is one of the concepts behind the double ring infiltrometer tests. Using the calculated hydraulic conductivity produces an infiltration rate into the saprolite of about 0.01 ft/yr. This in undoubtedly an underestimate by orders of magnitude. If we use the average recharge rate in Halawa Valley is about 8.8 in/yr or 2.1×10^{-3} ft/d. A hydraulic conductivity of 2.1×10^{-3} ft/d is a minimum value since Halawa Valley is not a wetland.

High Infiltration Rate at the Quarry Elevates the Water Table and Influences GW Chemistry at Red Hill

AECOM has for more than a year stated the focused recharge into the quarry pits likely creates in a groundwater mound, resulting in a hydraulic barrier between the Red Hill Facility and the Halawa Shaft. They further state that the quarry infiltration is responsible for the elevated chloride and alkalinity in the RHMNW wells. It is important to point out the wells with high alkalinity; RHMW01, 02, and 03 have low chloride; and the wells with high chloride; OWDFMW-1, RHMW06, and 07; have moderate alkalinity. Undoubtedly the removal of overburden and the steep slopes excavated during rock mining result in some increase in recharge in the quarry area. However, three things must be shown to confirm AECOM's hypotheses: 1) the recharge is sufficient increase the water table elevation significantly in the highly permeable lavas; 2) there is enough mass of carbonate and chloride to significantly increase the groundwater concentration of these species in wells nearly a half of mile from the quarry; and 3) that groundwater will flow from the quarry through the saprolite to the wells in the Red Hill Monitoring Network (RHMNW). To make this hypothesis scientifically defensible will require either direct measurement of the groundwater elevation and chemistry in a well on or near the quarry, or a comprehensive water budget study. The only number cited thus far is the 8 million gallons per month used by the Hawaiian Cement for their operations. In the permeable basalts where the specific capacities of wells are at least few hundred gallons per minute per foot of drawdown (infiltration or injection would produce a similar upconing) 8 million gallons per day or 185 gallons per minute dispersed over the quarry footprint falls far short of what would be expected to affect the groundwater elevation. It is important to note that specific capacity tests done on wells is focused in a very finite point. Infiltration in the quarry would be dispersed so the response of the aquifer would be much smaller. The infiltration would of course be supplemented by rainfall, but to estimate the amount of rainwater infiltration will required a comprehensive water budget analysis. This task does not seem to be part of the approach. It would be scientifically indefensible to contend that all or even a majority of the rainfall over the quarry infiltrates to the water table.

The Lava Beds Dip to South-Southwest

GSI's model of the LNAPL transport direction and footprint on the water is based on the estimated slope and direction of the lava beds. When queried about how the lava bedding geometry was arrived at, AECOM stated that outcrops had been surveyed. Further inquiries indicated that maybe the outcrop survey was not that robust. The lava bedding geometry is a very important parameter to estimate the direction and rate of travel of LNAPL in the unsaturated zone. The methods and supporting data need to be made available so performing the oversight can evaluate how robust the estimated lava bedding dip and direction calculations are.

Use of the RHMW07 and HDMW2253-03 Water Levels to Estimate Groundwater Gradient and Flow Direction

The use of RHMW07 and HDMW2253-03 to characterize the groundwater gradient and thus the inferred groundwater flow paths is a recurring theme at the Red Hill meetings, but their validity for this assessment is questionable. The abnormally high water table elevation and significant drawdown (0.1 to 0.2 ft) at very low flow rates when sampling strongly argue that the connection of RHMW07 to the rest of the aquifer beneath the Red Hill facility is through some poorly permeable media. There is no other well in the Red Hill Ridge that has a similar water level and such a slow response to pumping stresses at the Red Hill Shaft. HDMW2253-03 has an open interval that extends through the thickness of the freshwater lens. The water level measured in this well is a composite of the water a 1000 ft water column. The water level in HDMW2253-03 is about 1 ft higher than that at RHMW04, the most upslope well in the RHMNW. The quarterly conductivity/depth profile done by DLRN indicates that there is strong upward flow in the borehole that likely elevates the water surface in this well making this well a poor candidate for groundwater gradient analysis. RHMW06 that is located between RHMW07 and HDMW2253-03 and has a water table elevation 0.2 ft lower than in monitoring wells RHMW01, 02, 03, and 04. When the water table elevation in RHMW07 and HDMW2253-03 are considered the apparent groundwater gradient is toward the axis of the Red Hill Ridge. If the water table elevation in these two wells is not considered, the apparent groundwater gradient is to the northwest toward the Halawa Shaft. Currently neither gradient can be confirmed so the most conservative, and correct approach is to assume groundwater flow to the northwest.

Inferring a Groundwater Flowpath from a Chemical Mixing Diagram

AECOM contends that the Piper diagrams show groundwater flow along a mixing line from RHMW02 to OWDFMW-1. It has been repeatedly pointed out to them that the position of RHMW01, 02, and 03 on these diagrams is an artifact of the natural attenuation. The respiration of the microbes as they consume organic carbon increases the alkalinity of the groundwater as an increase in bicarbonate concentration. The groundwater flowpath that they hypothesize would be manifest by RHMW04 as one end member, OWDFMW-1 or the Red Hill Shaft as the other end member and RHMW03, 02, 01, and 05 falling near that line between the two end members. What the Piper Diagrams do shows is chemically different water with no apparent mixing trend between the wells. This was pointed out to them by UH when the results of the collaborative sampling was delivered to the Navy. Their insistence that the plots on the Piper Diagrams shows a mixing trend is both confusing and troubling in light of the fact that the problems with that conclusion have been repeatedly pointed out to them.

Groundwater Flow Around the Saprolite/Valley Fill is not Considered

The focus of AECOM's conceptual model is to show that valley fill/saprolite sequence in the Halawa Valley extends beneath the water table placing a barrier with low permeability between the Red Hill Facility and the Halawa Shaft. However, the 2015 USGS pump test showed that when the Halawa Shaft was not pumping, the groundwater elevation at RHMW04 was a foot higher than that at the Halawa Shaft. Water level monitoring to date also shows that the water level elevation in RHMW04 is no higher than that in monitoring wells that are located between the tanks. To determine whether or not groundwater (or LNAPL) beneath the USTs can flow to the Halawa Shaft, the point at which the bottom valley fill/saprolite sequence rises above the water table (going up valley) must be known. The proposed installation of RHMW13 may answer that question, but currently the answer is unknown and again flow from the beneath the USTs to the Halawa Shaft must be assumed until it is shown not to be true.

A similar situation exists at the southeast boundary of the model. The groundwater elevation beneath the Kalihi Ridge is higher than that beneath the Moanalua Ridge. The model runs presented at the meeting have no groundwater flow across the southeast boundary. This is the least conservative assumption. Unfortunately there is no way I know of to evaluate the groundwater flow direction and magnitude through the southeast boundary. The only possible option would be to assign groundwater fluxes at this boundary and evaluate whether this action moves the model results closer to or further away from what real data says. But if there is groundwater flow from Kalihi to Moanalua and from Moanalua to Halawa, the Halawa Shaft is at risk of being contaminated by a large fuel release at the Red Hill Facility.